# The Green Power Market Model (GPMM)

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# Overview of Green Power Markets

Green Power Market programs fall into two categories:

- Green Marketing programs- Deregulated markets
  - Selling green power in the competitive marketplace, in which multiple suppliers and service offerings exist
  - Currently offered in 9 states

- Green Pricing programs- Regulated markets
  - Programs sponsored by utilities that give customers the opportunity to pay extra to support the development and operation of green power sources
  - Currently offered in 32 states

# Options for Modeling Green Power Markets

Two Basic Approaches for modeling Green Power Markets

1) Estimating Demand through
   - Consumers' Willingness to Pay to estimate demand
   - Researching market experience of existing programs to measure effectiveness
     - Market Penetration (% of eligible customers)
     - Capacity built (MW) or generation provided (kWh)

2) Estimating the green power premium
   - The value of green power in the marketplace
   - Including this as a cost reduction in economic decision models

# Issues for Modeling Green Power Markets

The Green Power Market Premium

- Recent market surveys suggest:
  - Wholesale market premium is about $0.005/kWh
  - Retail market premiums average about $0.02/kWh

Modeling the payment method for Green Power Programs

- Programs generally use one of three different payment methods:
  - An additional amount per kilowatt-hour
  - A fixed amount each month for a block of energy
  - A percentage of the total bill

# Issues for Modeling Green Power Markets (cont.)

The choice of technologies to model as "green"

- Are renewables the only green technologies?
  - Programs generally include most renewable technologies
  - Certain programs only include solar and/or wind power
  - Hydropower and certain biomass technologies (LFG, MSW, and cofiring) are often excluded
  - Regional variation in green definition (often political)
- Some Green Power Certification agencies include non-traditional renewable energy technologies
- What technologies should be included?
  - Modelers should try to reflect actual experiences in the green power market

# Overview of PERI's GPMM

- Purpose
  - To project capacity additions resulting from green power programs not captured in the "least-cost" analysis of NEMS
- Results are hard wired into NEMS runs as planned capacity for DOE renewable energy programs' GPRA reporting
- The model projects green power capacity additions through both green power marketing & utility green pricing programs
  - Additional Capacity from other DOE program endeavors included (MSR)
- PERI originally constructed the GPMM in the summer of 2000

# Overview of PERI's GPMM (cont.)

- The GPMM is based in Microsoft Excel
- The model projects expected "green revenues" from a base of calculated green power customers
  - Assumed payment method - 10% of each customer's bill
- These funds determine the amount of green power generation
  - Calculated via the cost of energy (COE) per kWh
- Resulting capacity built is calculated from the generation
  - Capacity Factors assumed for each technology type

# Overview of PERI's GPMM (cont.)

- Model builds multiple competing technologies in each region, not only the least cost technology
  - Market sharing algorithm (i.e., a logit function)
  - Share of each technology inversely related to first-year COE

$$\text{Market Share}_{wind} = ((1/COE^{\lambda}_{wind}) / (\Sigma(1/COE^{\lambda}_{\text{all techs}}))$$

  - Higher cost technologies' inclusion is dependent upon scaling factor, lambda ($\lambda$)
    - $\lambda$ often ranges from 0 to 15 (Set to 3.2 in GPMM)
    - As $\lambda$ increases, lower cost technologies get a higher %

# Overview of PERI's GPMM (cont.)

- Regionalized approach (U.S. Census Regions)
  - Rationale - input data is often available in this format
- Eight Census Regions used:
  - 1) New England, 2) Middle Atlantic, 3) East North Central, 4) West North Central, 5) South Atlantic and East South Central (regions combined), 6) West South Central, 7) Mountain, and 8) Pacific
- Results are converted from 8 Census Regions to 13 NEMS regions, in order to be hard-wired into NEMS

# Assumptions of the GPMM

- Many of the major assumptions come from the recent report: Forecasting the Growth of Green Power Markets in the United States (Wiser, Bollinger, Holt and Swezey, 2001)
  - Except where noted, the GPMM uses the high-growth case assumptions
- State level data aggregated to Census region level
  - Weighted by electricity sales

# Detailed State-by-State Assumptions

Dates of initiation of market restructuring:

- IOU restructuring:
  - States already open to competition remain open
  - Pace of restructuring varies by state, but within five years of deregulation 100% of the IOUs markets will have active retail competition.

- Public Utility restructuring:
  - Starts at 2.5% in the 3rd year after IOU restructuring begins, and increases to 20% by the 10th year
  - Restructuring never fully includes all Public Utilities

# Detailed State by State Assumptions (cont.)

- Green Pricing Programs
  - A portion of those utilities still regulated in each state will offer green pricing programs
- Customer access to green power programs
  - Regulated markets - starts at 10% and increases by 5% per year to 60% in 10th year
  - Competitive markets - 100% assumed to be open
  - Regional percentage of all customers with access to green power programs grows to 63-91% by the end of the analysis

# Detailed State by State Assumptions (cont.)

Green power customer participation rates

- Regulated markets
  - Start at 0.75% for residential customers in 1st year, increasing by 0.75% annually to 7.5% in the 10th year
- Competitive markets
  - Starts at 1% and increases to 15% by 15th year.
- Commercial and Industrial customer participation rate
  - Combined 25% of the residential participation rate
  - 16.7% for commercial and 8.3% for industrial
- Participation rates for newly deregulated markets

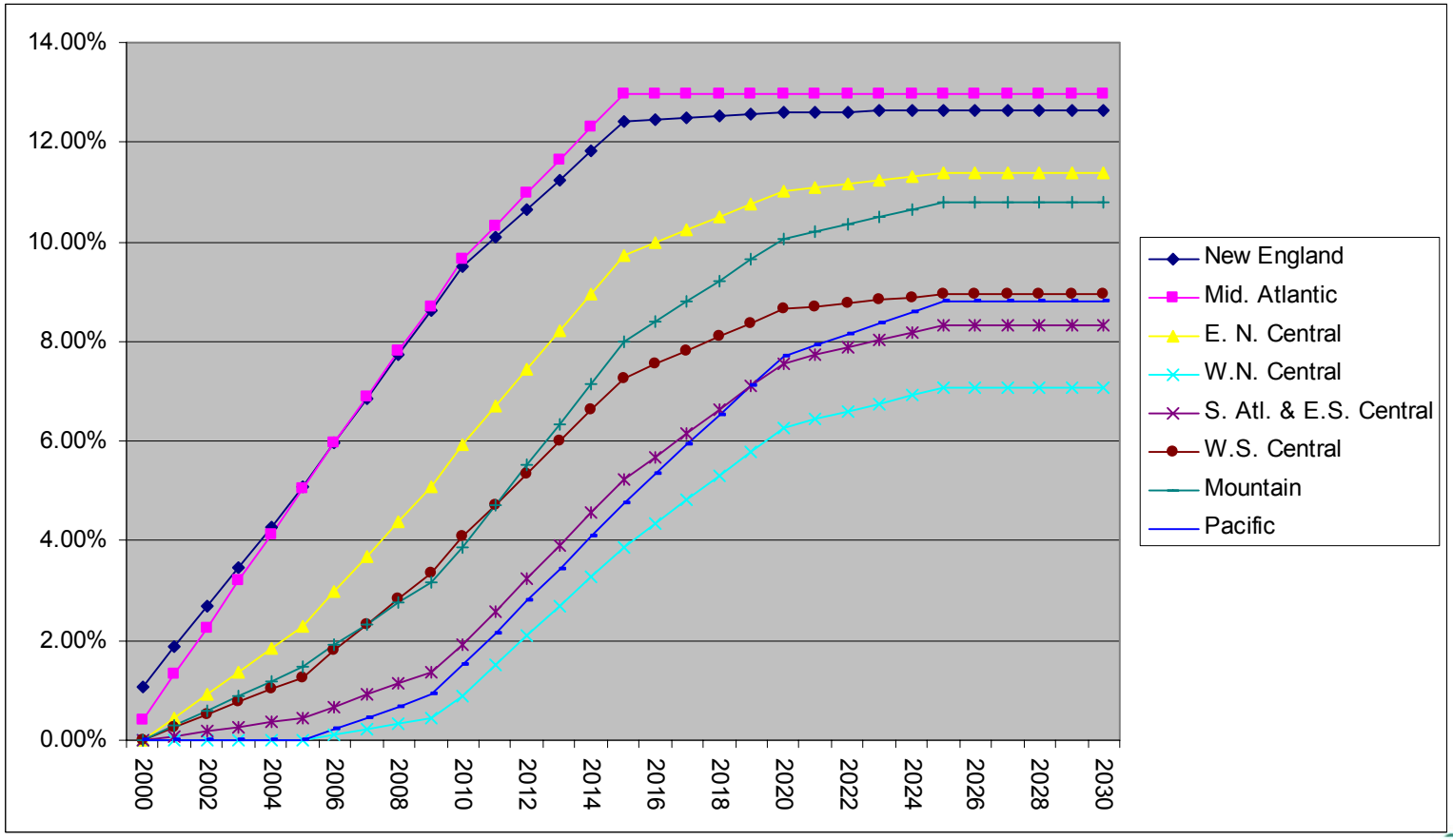
# Detailed State by State Assumptions (cont.)

**Table 1. Regional Participation Rates in Green Power Programs (as a % of all customers)**

| | 2000 | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| **New England** | 1.1% | 5.1% | 9.5% | 12.4% | 12.6% | 12.7% | 12.7% |
| **Mid. Atlantic** | 0.4% | 5.0% | 9.6% | 13.0% | 13.0% | 13.0% | 13.0% |
| **E. N. Central** | 0.0% | 2.3% | 5.9% | 9.7% | 11.0% | 11.4% | 11.4% |
| **W.N. Central** | 0.0% | 0.0% | 0.9% | 3.9% | 6.3% | 7.1% | 7.1% |
| **S. Atlantic & E.S. Central** | 0.0% | 0.4% | 1.9% | 5.2% | 7.6% | 8.3% | 8.3% |
| **W.S. Central** | 0.0% | 1.3% | 4.1% | 7.3% | 8.7% | 9.0% | 9.0% |
| **Mountain** | 0.0% | 1.5% | 3.9% | 8.0% | 10.0% | 10.8% | 10.8% |
| **Pacific** | 0.0% | 0.0% | 1.5% | 4.7% | 7.7% | 8.8% | 8.8% |

# Detailed State by State Assumptions (cont.)

**Figure 1.. Regional Participation Rates in Green Power Programs (as a % of all customers)**



# Other Key Assumptions of the GPMM

- Market rules are conducive to competition and customer switching, and customer understanding and participation continues to increase
- All customers continue in the programs once they have joined
- Only the money from new customers joining green programs each year is used to build new capacity
- All money collected from these programs goes towards building additional capacity

# Cost Assumptions of the GPMM

- Technology cost and performance data taken from the DOE/EPRI report, Renewable Energy Technology Characterizations
  - New program revisions to the TC report for wind and CSP
- All cost figures converted to 2000$, using GDP price deflators
- Developers build projects in least cost fashion (without back-up)
  - Reasoning is that green power programs only guarantee a certain % of total kWh provided will come from green sources
  - Programs can take the "green" electrons when and from where they are able

# Annual Energy Outlook Inputs

- Data taken from EIA's most recent *Assumptions to the Annual Energy Outlook 2003*, (AEO03)
- The number of customers by economic sector for each region is determined by:
  - Residential Sector - number of residential housing units
  - Commercial sector - amount of commercial floorspace
    - Assuming 13,000 square feet per establishment
  - Industrial sector - the industrial gross output
    - Assuming $10 million of gross output per establishment
- Regional energy consumption and prices were taken from AEO03 Supplemental Data Tables

# Other Input Data Sources

The GPMM includes both additions and subtractions to the green power capacity builds from the following sources:

- Million Solar Roofs (MSR) – Added to Model Results
  - Projections by the Solar Energy Program
  - Accounts for over 4300 MW (99% GPMM builds) of PV additions
- EIA "Floors" Builds – Subtracted from Model Results
  - Capacity already assumed by EIA to be installed for reasons other than least-cost electricity supply
  - Includes 279 MW of PV and 63.4 MW of solar thermal

# Timeframe of the GPMM

- The model projects capacity additions for 2005 to 2035.
- Incremental green power market participation rates are projected to increase over the next ten years, and then decline
  - 2005 – 2015: Increasing incremental additions
  - 2016 – 2035: Decreasing incremental additions
- Revised start dates of restructuring according to EIA's *Status of State Electric Industry Restructuring Activity* updates
  - January 1, 2008 start date for states with no pending legislation

# Technologies Represented in the GPMM

- 13 individual technologies, (5 technology types), were selected as both green and commercially viable for this analysis:
- **Biomass:** Direct Fired, Gasification, and Landfill Gas
- **Geothermal:** Flash, Binary, and Enhanced Geothermal Systems
- **Concentrating Solar Power:** Solar Thermal Trough, Solar Thermal Dish, and Solar Central Receiver
- **Photovoltaics:** Residential, Central Station, and Concentrator
- **Wind:** Wind Turbines (composite of Class 4 and Class 6 turbines)

# Regional Variation Represented in the GPMM

- Resource-based regional distinctions are introduced via adjustment factors (AF):
  - AF > 1 implies the resource is more prevalent in that region
  - For example, solar insolation is higher in the West South Central region and lower in New England than national avg., so for PV - 1.17 AF in W.S. Central and 0.92 AF in New England
- Some technologies are excluded from certain regions
  - Due to prohibitively high costs or absence of a resource base
  - Examples:
    - Geothermal- restricted to Pacific and Mountain regions
    - Central Receivers- restricted to western regions
    - Wind turbines- excluded from the southeast.

# Results of the GPMM

- Results of the FY05 GPMM are shown in Table 2 (next slide)
- PV and Wind technologies receive the bulk of the capacity builds at about 40% each
  - However, over 98% of the PV builds due to MSR program
  - Excluding MSR and EIA "Floors"- wind is 60% of capacity
    - Expected, as wind is least cost technology
- Geothermal limited due to exclusion from all but 2 regions
- CSP built primarily in southeast region (i.e., wind is excluded)
- Biomass limited due to higher COE's for Direct Fired and Gasification, and regional limits for LFG

# National Results of the FY05 GPMM

**Table 2. Cumulative Capacity Installed by Technology Type (MW)**

| | 2005 | 2010 | 2015 | 2020 | 2025 | 2030 | 2035 |
|---|---|---|---|---|---|---|---|
| Biomass (incl. LFG) | 18 | 150 | 377 | 558 | 654 | 706 | 732 |
| Geothermal | 4 | 91 | 295 | 485 | 585 | 628 | 649 |
| CSP | 3 | 137 | 470 | 738 | 890 | 994 | 1,045 |
| PV | 70 | 866 | 2,789 | 4,343 | 4,834 | 4,942 | 4,996 |
| Wind | 212 | 1,781 | 3,495 | 4,246 | 4,661 | 4,907 | 5,030 |
| Total | 307 | 3,025 | 7,426 | 10,371 | 11,623 | 12,176 | 12,453 |

# Comparison of Results to Real World Experience

- "Real world" experience taken from Bird and Swezey report: *Estimates of Renewable Energy Capacity Serving Green Power Markets in the United States* (NREL, February 2003)
  - Estimates that 982 MW have been built for green power markets
- A sensitivity analysis was run to compare results of GPMM with these reported real world results
  - The model was run for years 1999-2002 only
  - Results are compared on the next slide in Table 3

# Comparison of Results to Real World Experience

**Table 3. Comparison of Capacity Additions to meet Green Power Programs (MW)**

| Renewable Technologies | NREL-2003 Report* | FY05 GPMM for time period 1999-2002 | | | |
|---|---|---|---|---|---|
| | | Initial Model Results | MSR added | Floors subtracted | Final Results |
| Biomass (incl. LFG) | 45 | 31 | | | 31 |
| Geothermal | 10 | 7 | | | 7 |
| CSP | 5 | 10 | | 3.3 | 7 |
| PV | | 0 | 92 | 0 | 92 |
| Wind | 913 | 573 | | | 573 |
| Total | 982 | 621 | | | 710 |

***The NREL report total contains 8.5 MW of small hydro, which is not modeled in the GPMM, and 4.8 MW of "solar" capacity.**

**- This comparison suggests that, at least for the early years of the analysis, the FY05 GPMM is conservative in its predictions.**

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